APPLIED REGIONAL MONITORING OF THE VERNAL ADVANCEMENT AND RETROGRADATION (GREEN WAVE EFFECT) OF NATURAL VEGETATION IN THE GREAT PLAINS CORRIDOR

Principal Investigator:
John W. Rouse, Jr.
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College Station, Texas 77843

September 1975
Type II Report for Period February 1975-April 1975

Prepared for:
Goddard Space Flight Center
Greenbelt, Maryland 20771

Contract No. NAS5-20796

TEXAS A&M UNIVERSITY
REMOTE SENSING CENTER
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1. BACKGROUND SUMMARY

1.1 The 18 month LANDSAT Follow-On Investigation 20540 is a regional expansion of the LANDSAT-1 investigation entitled "Monitoring the Vernal Advancement and Retorgradation (Green Wave Effect) of Natural Vegetation". The initial study was restricted to evaluating the discrimination of land use patterns and recognizing the phenological development at sites of known plant/soil composition. As expressed in the work statement of contract NAS 5-20796, three tasks are to be addressed during the course of this follow-on study. The first task involves the acquisition and analysis of satellite imagery and computer compatible data from natural vegetation systems in the Great Plains Corridor. The second task involves the acquisition of aerial photography, certain coordinated ground truth data, and environmental data in support of the satellite imagery and digital data. The third task relates to the correlation and analysis of satellite and support data for testing certain specific hypotheses important in evaluating the feasibility of an

operational system for monitoring the status of natural vegetation in the Great Plains. The hypotheses to be tested are:

Hypothesis Number 1--Time is an important factor in the discrimination of broad landforms, soil associations, vegetation types and other natural resources features.

Hypothesis Number 2--The vernal advancement and retrogradation of vegetation (Green Wave Effect) can be discriminated on a regional basis using repetitive multispectral imagery.

Hypothesis Number 2--Vegetation systems parameters are adequately unique to provide a new information source for regional agri-business use.

To test the three hypotheses and to evaluate the application of LANDSAT data within the Great Plains region, the following specific objectives are to be addressed:

Objective Number 1--To develop a data analysis methodology that will facilitate the extension of regional satellite data.

Objective Number 2--To chart the vernal advancement and retrogradation of natural vegetation on a regional basis using LANDSAT data.

Objective Number 3--To record the phenological events and collect specific biological and environmental data using an effective test site network for ground observations.

Objective Number 4--To apply LANDSAT sensor measurements for identification of rangeland vegetation and soil types, measuring short-term and seasonal vegetation reflectance changes, and evaluating the impact of environmental conditions on dominant vegetation.

Objective Number 5--To evaluate the feasibility of using LANDSAT-type data, in conjunction with geographic and climatological parameters for modeling a range forage index and indexes of plant growth conditions.

1.2 Summary

During the first quarter of this contract, February-April 1975, activities were dedicated to developing resource and land use data overlays for all sites, developing the ground data acquisition program and putting it into operation, developing technical details of the computer processing approach to the forage map end products, and finalizing NASA high-flight specifications for the aerial photo coverage to be flown for all the Great Plains Corridor sites.

To accomplish these aims TAMU investigators selected and acquired a set of image and supportive data for resource mapping of all the sites. Preliminary resource and land use mapping was completed on the base images from these data and utilized in locating probable field measurement sites. The investigators personally visited the cooperators and their respective Great Plains Corridor test sites and selected ground sampling sites. In addition, the test site cooperators assisted in selecting other areas within the base LANDSAT image sets including their test sites, which are similar to and would be representative of the ground sampling sites. NASA high-flight photo coverage of the test sites was planned and flight line specifications sent to NASA/ Lyndon B. Johnson Space Center in preparation for the June flights.

The computer processing approach to producing maps of forage amount and range condition as final products was delineated. Steps were taken to find the best method for producing computer data overlays. The overlays will consist of LANDSAT data vegetation index values, (Transformed Vegetation Index, developed under the LANDSAT-1 contract), precipitation, and temperature data from which green biomass calculations can be made

over the extended regions around the cooperators' sites as well as the North Central Texas area. A search was begun for an efficient and accurate contouring program which could be used to produce the vegetation condition maps.

Dissemination of technical information through presentations and publications was accomplished during the quarter. An unpublished presentation was delivered to the Annual Convention of the Society for Range Management in February concerning the general aspects of both the LANDSAT-1 and the present follow-on experiment. An article was published in Information Report #75-1 by the Texas Agricultural Experiment Station. An abstract concerning grazing treatment results of the LANDSAT-1 investigation was submitted to the Tenth International Symposium for Remote Sensing of the Environment.

1.3 Organization of the Report

The body of this Type II progress report is organized along the lines suggested in the contract statement of work. Section 2 (Accomplishments and Problem Areas) discusses details of the approach taken on this project and the tasks undertaken during the quarter for both data acquisition and analysis. It also delineates

problems encountered and the effect they had on project activities, recommendations concerning the project and accomplishments expected during the next quarter.

Section 3 (Significant Results, Publications and Presentations) relates significant results obtained during the quarter and lists publications and presentations distributed during the quarter. Section 4 (Funds Expended and Data Status) presents the total expenditures during the quarter towards this project from three sources: TAMU contract funds; TAMU matching funds; and NASA high-flight photography and LANDSAT data accounts at both EROS Data Center and the ASCS Aerial Photography Field Office. The data expenditures are treated separately from the others and in the manner specified by the contract. Section 5 (Aircraft Data Usage) describes the ways in which aircraft data supplied by NASA have been utilized in the project activities.

2.0 Accomplishments and Problem Areas

2.1 Accomplishments During the Reporting Period

2.1.1 Project Approach

The initial LANDSAT-1 Great Plains Corridor rangeland investigation incorporated the use of ten test sites throughout the Great Plains from South Texas through North Dakota. Vegetation parameters were measured at sampling sites at these test site locations in conjunction with LANDSAT-1 overpasses. The relationships between ground measurements of vegetation and LANDSAT multispectral scanner (MSS) measurements were established. A close relationship between MSS baud ratios and ground measured green biomass prompted the development of a model for measuring rangeland vegetation conditions with satellite sensors.

The basic concept behind the follow-on investigation is to apply the techniques for monitoring rangeland vegetation conditions on a regional basis. It is anticipated that satellite data have applicability for monitoring rangeland vegetation conditions throughout the Great Plains. However, the validity of the MSS data measurements for evaluating vegetation conditions, must be first tested across this large land area.

Budgetary constraints on the project preclude the processing of data and collecting necessary ground verification for all rangeland areas of the Great Plains. Therefore, large areas within the Great Plains Corridor (GPC), which included the established test site locations, were selected for conducting this investigation.

The nominal north to south LANDSAT tracks which provide coverage of each of the test sites were designated as defining the east-west boundaries of the follow-on investigation TEST AREAS. Essentially cloudfree LANDSAT-1 imagery acquired during the growing season within these tracks were selected to provide coverage of the test sites and for establishing the approximate north and south boundaries of the test areas. The north-south boundaries conform to the nominal LANDSAT-1 coverage as shown in Figure 2-1. The LANDSAT-1 images that were selected to establish these test areas are listed in Table 201. Sonora and Weslaco, Texas test sites are not being used in the follow-on investigation due to the apparent influences of dense brush encountered during the initial investigation. Funding constraints did not permit the additional research required to resolve problems encountered with predominantly-brush covered rangelands.

An area encompassing much of the Rolling Red Plains and North Central Prairies vegetational regions of Texas and Oklahoma was selected as the primary test site and will be employed for extensive ground data collection for model testing and data processing technique evaluation. This test area is called the "Extended Test Site Area", hereinafter generally referred to as the ETSA. The ETSA is a 250 km by 250 km square, which encompasses 6.25 million hectares (24,100 square miles or about 15.5 million acres). Figures 2-2 and 2-3 show the ETSA which includes the Throckmorton test site near its center.

Ground sampling locations within the ETSA will be selected utilizing a vegetation/soil resource map, which is to be produced from the base imagery set, NASA highflight aerial photograph, and field verification. These locations, as well as the other Great Plains Corridor test areas, will be sampled coincidentally with three or four LANDSAT-2 overpasses during the growing season. It is anticipated that two of these sampling periods will be in the spring, one in mid-summer, and one in early to mid-fall.

The computer processing aspect will entail the development of programs to store and retrieve soil, vegetation, topographic, climatological and weather data,

Figure 2-1. Great Plains Corridor test areas as defined by selected LANDSAT images

Table 201. Base imagery set for test areas from LANDSAT-1 overpasses.

TEST AREA	OBS. I.D. NO.	DATE
Mandan, North Dakota	1297 - 17063	5-16-73
	1297 - 17065	5-16-73
Cottonwood, South Dakota	1297 - 17072	5-16-73
	1297 - 17074	5-16-73
Sand Hill, Nebrasks	1295 - 16562	5-14-73
	1295 - 16564	5-14-73
Hays, Kansas	1329 - 16461	6-17-73
Woodward, Oklahoma	1329 - 16463	6-17-73
	1329 - 16463	6-17-73
Chickasha, Oklahoma	1454 - 16383	10-20-73
	1454 - 16385	10-20-73
Throckmorton, Texas	1454 - 16385	10-20-73
(ETSA)	1454 - 16392	10-20-73
	1455 - 16444	10-21-73
	1455 - 16450	10-21-73
College Station	1452 - 16282	10-18-73
	1452 - 16284	10-18-73

and other information about any location within the test areas for model input. The UTM grid system will be used for referencing and identifying areas being studied. Another phase will involve program development and testing for extracting, processing, and displaying MSS-derived functions, such as the range forage condition index. The ground truth data will be compared with the results of computer processed LANDSAT MSS data obtained coincidentally at these test areas to evaluate the success of the procedures and model and to develop other models as necessary.

2.1.2 Project Tasks Accomplished

Early in the project existing LANDSAT imagery for the Great Plains region was searched for the evaluated via microfilm to select a good base imagery set for resource mapping in the areas under investigation. The color composite images which define the test areas were ordered, received and mapping activity initiated.

Categories of land surface features that were found to be easily mapped include urban and agricultural land, water resources, rangelands, and forests and woodlands. These features were mapped on the 1:1 million scale images for all Great Plains Corridor test areas.

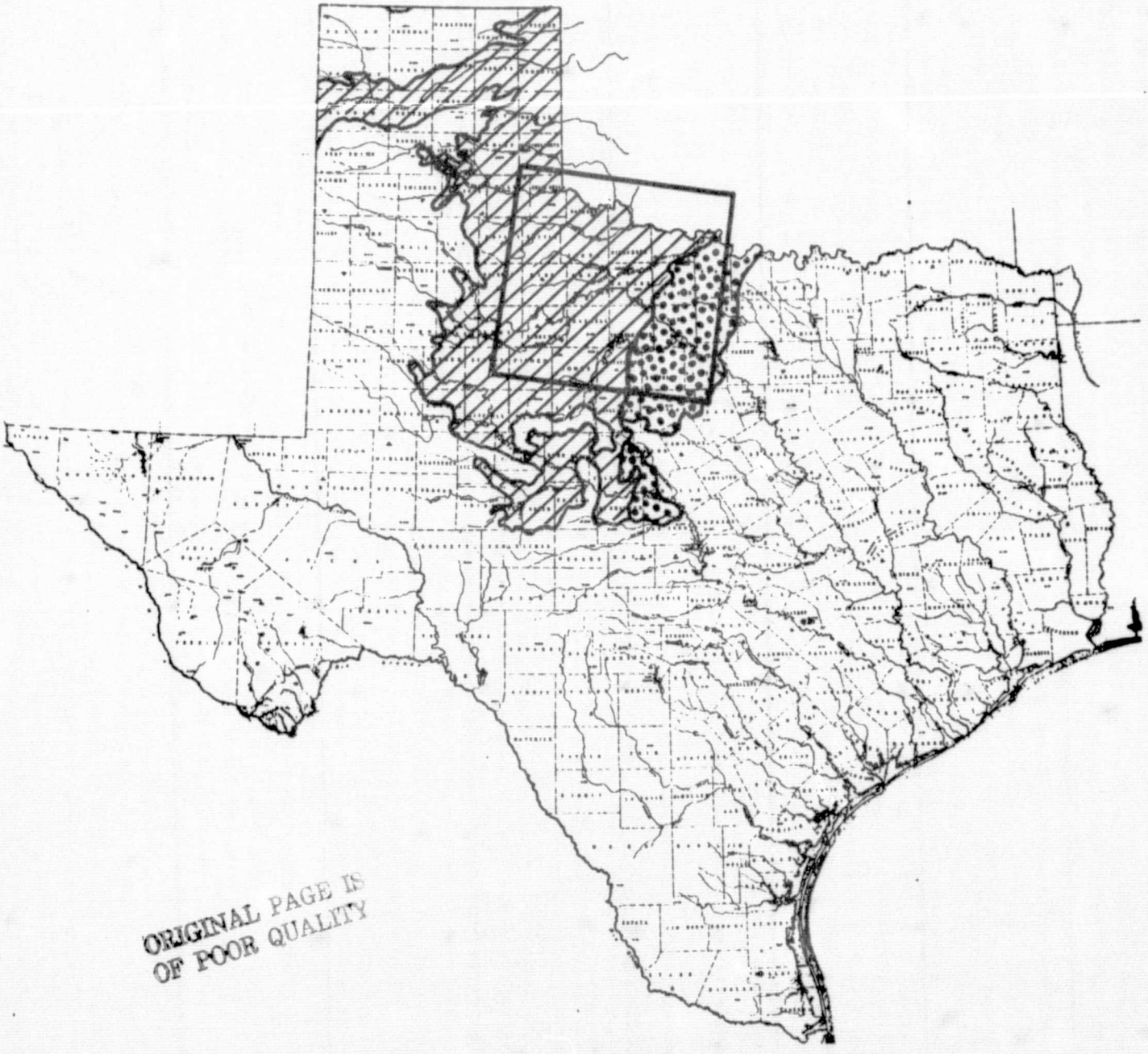

Figure 2-2. The Extended Test Site Area shown in relation to the Rolling Plains (hatched lines) and North Central Prairies stippled vegetational areas in Texas.

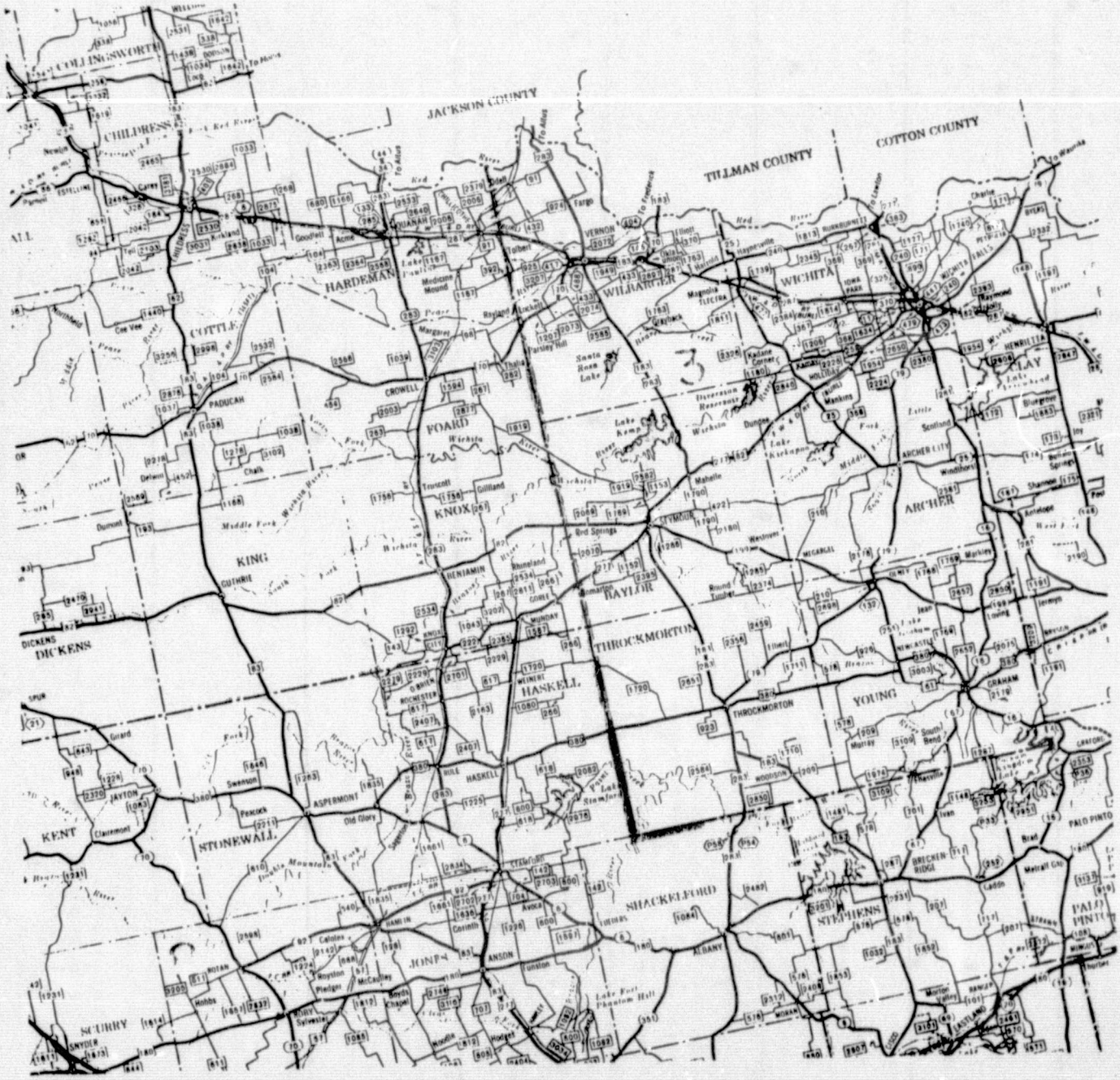

Figure 2-3. The counties, cities, and highways in the Texas portion of the Extended Test Site Areas.

More intensive mapping was undertaken using color balanced LANDSAT imagery from the four seasons in three years for the Extended Test Site Area in the Texas and Oklahoma Rolling Plains. After mapping the land surface features, a ground reconnaissance trip was taken throughout much of this study area. Field records were made for locations visited along a pre-determined route. These records, which include notes on the physiographic and vegetative characteristics of each site were used to develop a land resource classification system (APPENDIX A). This tentative land classification system is a preliminary step in the development of a larger computer compatible legend system. This legend system, which utilizes a numerical notation system to describe delineated land units, will ultimately be expanded to encompass all natural vegetation areas in the Great Plains Corridor.

Following the completion of the ground survey and the development of the legend system, a more detailed map of the rangeland resources was produced using four LANDSAT color composite enlargements at 1:250,000 scale. The rangeland vegetation types were delineated and annotated on the photos with the proper legend code. Map-

ping of the vegetation of the ETSA was a primary step toward the selection and establishment of sampling locations to be intensively surveyed on the ground and from low altitude aerial photography.

The locations of weather recording stations within the ETSA were determined and plotted on an overlay of the range resource map. Weather station information such as length of record, mean precipitation, etc., were acquired.

The optimun locations for NASA high-flight coverage were determined from these maps and potential ground sampling locations were selected on the basis of accumulated information. Flight line locations were finalized for all GPC test areas and a flight request was submitted to the aircraft support program office. The 1500 miles of flight line coverage requested from NASA is shown in APPENDIX B.

During this reporting period, the test sites in the northern states were visited (Kansas, Nebraska, South Dakota, and North Dakota). The cooperative arrangements were made for ground data acquisition during the 1975 growing season. Schedules of satellite overpass were provided for the cooperators with the anticipated sampling dates indicated. Revised data collection forms

were supplied and modified sampling procedures discussed. A visit was made to the test site areas and additional sampling sites were established. In all cases the number of sampling sites was at least doubled over that used in the initial LANDSAT-1 study in order to provide a more reliable and accurate record of vegetation condition.

The test site cooperators evaluated the preliminary resource map overlays and assisted Remote Sensing Center personnel in identifying areas for possible use as extension sites for LANDSAT data processing.

2.2 Problem Areas

No insurmountable problems were encountered during this first reporting period, but three areas of concern were recognized.

Mapping from color composite LANDSAT imagery, especially for 2 large areas requiring more than one image frame, required accurate depiction of the spectral signatures of features being mapped. Maximum feature contrast is required and like features in adjacent images should appear the same (assuming the same ground conditions). This requires high photographic quality and normally entails special color balancing procedures in

the photographic lab. The cost for these services was increased at the Western Aerial Photo Lab (USDA, Salt Lake City, Utah) by 300% during this reporting period. This presents a significant problem for mapping large areas from LANDSAT color composite imagery.

A second problem results from the cut in flight line miles allowed for this project for NASA high-flight aerial photographic coverage. This restricts the data base to a suboptimim level. The original proposal requested coverage of the 1500 line miles during two optimim seasons, whereas the data base will consist of one season coverage. Less desirable, less efficient, and less accurate alternatives will have to be chosen to acquire the necessary information about the test area vegetation.

A final observation is that weather conditions during the early part of 1975, at the close of the reporting period, indicate a somewhat "atypical year." At this time it appears that the Great Plains region will experience a late spring with cool weather delaying spring development of vegetation.

2.3 Recommendations

At this initial phase of the investigation, no recommendations resulting from the research can be made.

2.4 Scheduled Accomplishments for the Second Quarter

It is anticipated that during the second quarter the remaining test sites will be visited to prepare for the spring sampling. Ground data collection will be initiated in mid to late May. The scheduled June and July samples will also be taken. This will constitute the bulk of the temporal vegetation monitoring for this project.

Following a review of NASA high-flight aerial photography, which will be acquired during the early part of the second quarter, a sampling site selection trip will be conducted in the ETSA. Final sampling locations throughout this region will be made. Vegetation sampling at these locations will be carried out in conjunction with three LANDSAT-2 overpass periods. Medium altitude aerial photography will be acquired along lines including the sampling locations.

3. Significant Results, Publications and Presentations

3.1 Significant Results

During the first quarter of this contract, no significant results were obtained since the period was spent in preparation for the field measurement and data analysis stages of the project.

3.2 Publications and Presentations

Three papers and presentations were produced during the period February-April 1975. Most, but not all, covered the general aspects of the techniques developed under the LANDSAT-1 Great Plains Corridor NASA contract and the intent of this follow-on experiment.

D. W. Deering presented the unpublished paper "Satellite Monitoring of Rangeland Resources in the Great Plains Region" to the 28th Annual Convention of the Society for Range Management. This was a semi-technical paper and was presented on February 13, 1975 in Mexico City.

R. H. Haas and D. W. Deering co-authored a two-page article for the Texas Agricultural Experiment Station Information Report 75-1, Grazing Management, Beef Cattle Production, and Brush Control. This article was entitled " Satellite Measurement of Range Forage Condition".

An abstract, "Measuring 'Forage Production' of Grazing Units from LANDSAT MSS Data" was submitted to the Tenth International Symposium of Remote Sensing of Environment. This was co-authored by D. W. Deering, J. W. Rouse, Jr., R. H. Haas, and J. A. Schell and will be a technical paper concerning the details of this one aspect of the LANDSAT-1 and follow-on experiments

4. FUNDS EXPENDED AND LANDSAT DATA STATUS

4.1 Total Expenditures To Date

Expenditures under this contract are divided here into three categories for the purpose of discussion: TAMU contract expenditures; those from TAMU matching funds; and NASA expenditures. The items considered under NASA expenditures as accountable directly to this project are those for LANDSAT imagery, LANDSAT CCT data and the high-flight aerial photo on accounts set up with the EROS Data Center and the ASCS Aerial Photography Field Office. Table 4-1 gives the total expenditure for the quarter under each of the categories.

4.2 Data Status

Three data accounts have been established for this project. Both a LANDSAT imagery account (20540) and an aircraft imagery account (20540 AC) have been set up with the ASCS Aerial Photography Field Office. A LANDSAT CCT data account is in effect with the EROS Data Center. Table 4-2 lists the budgeted amount, the amount ordered, and that received for each account during the quarter.

Table 4-1. First Quarter Expenditures

	Budgeted	Expended	Balance
TAMU Contract	97000.00	8682.02	88317.98
TAMU Matching Funds	58700.00	3261.00 (av./mo.)	55439.00
NASA Data Accounts	29200.00	694.00	28506.00

Table 4-2. Data Expenditure T! bulation

Account	Value of Data Allowed	Value of Data Ordered	Value of Data Received
ASCS LANDSAT Imagery (20540)	1800	694	694
ASCS Aircraft Imagery (20540AC)	2640	-0-	-0-
EROS CCT Data (GB0540)	24800	-0-	-0-

5. AIRCRAFT DATA USAGE

The first high-flight aerial coverage of the Great Plains Corridor test sites was requested to be flown during June 1975. Therefore, there is no report to be made on aircraft data usage for this quarter.

APPENDIX A

TENTATIVE LAND CLASSIFICATION OF GPC TEST SITE IN NORTH CENTRAL TEXAS

Symbolic and Technical Legend

10. Urban

20. Agricultural Land

30. Rangeland

    31. Grassland and herbaceous types

        31.1 North Central prairie (Little bluestem/ Sideoats grama)

        31.2 Mixed grass prairie (Sideoats/Texas winter grass/Buffaloe grass)

        31.3 Shortgrass prairie (Buffaloe grass)

    32. Shrubland types

        32.1 Mesquite/Little bluestem/Sideoats grama

        32.2 Mesquite/Lotebush/Mixed grass

        32.3 Mesquite/Mixed shrub/Shortgrass

        32.4 Mesquite/Sandsagebrush/Sand dropseed

        32.5 Sand shinnery oak

        32.9 Shallowland, mixed shrub

    33. Savanna-like types

        33.1 Liveoak/Mesquite

        33.2 Post oak/Mesquite

        33.3 Juniper breaks

40. Forest and Woodlands

    43. Mixed

        43.1 Oak-Juniper Woodland

        43.2 River bottomland (Phreatophyte and riparian vegetation)

50. Water

    51. Streams and waterways

    52. Lakes and ponds

    53. Reservoirs

60. Barrenlands

Descriptive Legend

1.0 Urban - includes the residential, business, transportation and industrial sectors of cities and towns.

2.0 Agricultural Land - includes field and row type cropland, pasture, orchards, vineyards, etc.

3.0 Rangeland - natural vegetation types other than forest and woodlands

3.1 Grassland and herbaceous types

3.11 Little bluestem/sideoates grama - includes the north central prairie. Found in the northwest portion of the study area.

3.12 Mixed grass prairie - this type occurs primarily as a result of brush control practices aimed at mesquite. Over time this type will revert to a mesquite/lotebush/ mixed grass type if mesquite is not continually controlled. Common grasses include buffaloe grass, Texas winter grass, sideoats grama, and sand dropseed.

3.13 Shortgrass prairie - buffaloe grass is the prominent grass species. Other grasses include Texas winter grass/sideoats grama, and Arizona cottontop.

3.2 Shrubland type

3.21 Mesquite/little bluestem/sideoats grams- essential north central prairie type with mesquite invasion.

3.22 Mesquite/lotebush/mixed grass - the most extensive type occurring throughout the study area found on primarily four range sites; shallow and deep hardland, shallow upland and rolling disected hills. Production on this type is effected by two primary factors; past brush control and grazing history, and site potential. The M/L/buffaloe grass community with associated grasses such as Texas wintergrass and Arizona cottontop is the dominant vegetation community in this type. Other plant communities include M/L/ western wheatgrass found in swales and along waterways; and the M/L/tobosagrass community found in heavy clay lowland sites.

3.23 Mesquite/mixed shrub/shortgrass - similar to M/L/mixed grass type except for increase shrub diversity and increased prominents of buffaloe grass. Additional shrubs

include ephedra, and wolfberry. This type is found primarily in the southwestern portion of the study area.

3.24 Mesquite/sandsage brush/ sand dropseed - found primarily in the northeastern portion of the study area on sandy soils, and slightly rolling hills.

3.25 Sand shinnery oak - found in the northwestern and southcentral portion of study area. Confined to sandy soils. Grows in association with mesquite and sandsage brush, and sand dropseed.

3.26 Shallow land, mixed shrub - found in north-central portion of the study area on shallow, highly erodable soils (Vernon complex). Low production site. Shrub diversity is high including shad scale, four wing salt brush, mesquite, juniper, ephedra, indigobush, wolfberry, etc. There are several distinct communities in this type but they are small and largely controlled by microrelief and soil conditions.

3.3 Savanna-like types

3.31 Live oak/mesquite - found in the southcentral to southeastern portion of the study area in valleys and gentle sloping uplands. The relative prominents of live oak dimenishes in respect to mesquite as one moves from the southeast to the southwest. In several areas mesquite has been tree grubbed leaving a live oak grassland type.

3.32 Post oak mesquite - found along the east central portion of the study area. Cover value ranges to light (≤5%) to dense stands (>50%). In association with mesquite in the dense stands, and with elm, chittumwood, greenbriar and blackjack oak in denser stands.

3.33 Juniper breaks - the second most extensive vegetation type inthe study area. Found on rough dissected slopes along river drainage and on rough broken land. Juniper is generally confined to sloped off ridges and drainages. It is often found in patches on excarpments or on steep slopes with skunk brush, or in small flats and gentle slopes with mesquite and lotebush. Grasses commonly

in association with Juniper include silver bluestem, slim tridents, and three awn.

4.0 Forest and Woodlands

4.3 Mixed - mixed evergreen and deciduous tree species.

4.31 Oak-Juniper Woodland - found in southeastern portion of study area around Possum Kingdom Reservoir. Occurs on the slopes and ridges of hilly land. There's a high diversity of oak and other woody species. In general oak tends to dominant north facing slopes while Juniper dominant south exposed slopes.

4.32 River bottom land - includes phreatophyte and riparian vegetation along streams and waterways. Distinct communities are apparent and include such types as the Elm/Hackberry/ Cottonwood community and salt cedar communities.

5.0 Water

5.1 Stream and waterways

5.2 Lakes and ponds

5.3 Reservoirs

6.0 Barrenland - no types were delineated as such in the study area. This type includes rocklands, badlands, sanddunes and beaches, etc.

APPENDIX B

Flight Lines For Requested NASA

High Flight Aerial Photography